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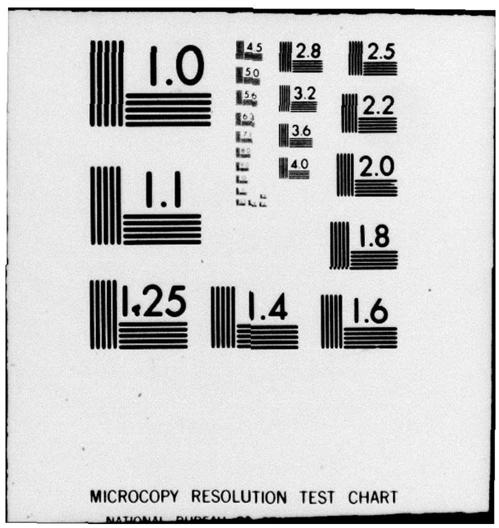
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Planar sub-millimeter and near-millimeter antennas have been studied. These antennas are suitable for integration with mixer diodes and infrared detectors. Antenna-coupled microbolometer far-infrared detectors have been built. These offer an advantageous combination of room-temperature operation, detectivity, and speed. Integrated antenna-coupled Schottky diode mixers are being developed.

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I. Statement of Problem Studied: This grant is concerned with development of near-millimeter and sub-millimeter infrared detectors and mixers. Aspects of particular interest are the use of antennas as adjuncts to detectors, and the integration of antennas with diode detectors and mixers.

A. Antenna-coupled detectors. We have shown that many kinds of infrared detectors can be improved through the use of antennas as receptors for radiation. In the reporting period we have concentrated on the development of antenna-coupled microbolometers. These are thermal infrared detectors that have dimensions small compared with the wavelength being received. In general, smaller thermal detectors have better responsivity, lower NEP, and faster response than similar detectors with larger dimensions. The task of radiation capture is performed by the antenna, which concentrates the radiation energy and applies it to the small detector. Our work in this area has dealt with development of detectors based on this principle and evaluation of their performance.

B. Integration of Antennas with Diodes. Diodes, in particular Schottky diodes, are useful as detectors and mixers at near-millimeter and sub-millimeter wavelengths. At these wavelengths, hollow waveguides become inconveniently small, and it appears better to dispense with them and couple radiation directly into the diode by means of an antenna. Cat-whisker type antennas have generally been used for this purpose. However, cat-whisker antennas are delicate and fragile, and are difficult to replicate into arrays. It seems desirable to construct integrated planar assemblies, composed of diode, antenna, and perhaps other elements such as waveguides, diplexers, or filters. Such assemblies would then lend themselves well to replication for detector or mixer arrays. Our objective in the reporting period was to fabricate integrated combinations of antennas and Schottky diodes.

II. Summary of Results

A. Preliminary experiments were conducted to show that antennas could in fact be used as radiation collectors for infrared detectors. The results were reported in:

"An Antenna-Coupled Photovoltaic Detector," by T.-L. Hwang and S.E. Schwarz, Appl. Phys. Lett. 31, 101-104 (15 July 1977).

Abstract:

An infrared receiving antenna has been used to couple 3.39-μ radiation into an InSb photovoltaic detector. Use of antennas as noiseless collectors of radiation can potentially increase detectivity in many infrared detectors.

B. Design of planar infrared sub-millimeter antennas was studied. Significant insights were obtained into the problems of such antennas. Results appeared as:

"Infrared and Submillimeter Antennas," by D.B. Rutledge, S.E. Schwarz, and A.T. Adams, Infrared Physics 18, 713-729 (1978).

Abstract:

The special characteristics of infrared antennas are considered. In particular, we consider the unusual shapes and large dimensions which arise in practical cases, and the desirable planar structure in which an antenna is deposited on a dielectric substrate. Imperfect metallic conduction at high frequencies is also considered. Consequences for design are discussed in a qualitative fashion. Specific cases of interest have been studied by microwave modelling. A promising design for a planar antenna, consisting of a vee antenna with dielectric substrate and superstrate, is developed and studied by microwave simulation. It is found to have a single-lobed pattern well-suited for coupling to a primary mirror, with a gain of about 15 dB.

C. Based on the results of (B), above, the first planar antenna with predictable pattern at sub-millimeter wavelength was demonstrated:

"Planar Sandwich Antennas for Submillimeter Applications," by T.-L. Hwang, D.B. Rutledge, and S.E. Schwarz, Appl. Phys. Lett. 34, 9 (1 January 1979).

Abstract:

A planar receiving antenna with a predictable pattern at submillimeter wavelength is demonstrated experimentally for the first time. It is single-lobed and efficient, with a gain of approximately 8 dB at a wavelength of 119 μm.

D. The use of antennas with ultra-small thermal detectors was studied. An antenna-coupled microbolometer was developed. This detector, which operates at room temperature, is intended for applications similar to those for which pyroelectric detectors are now used. It has detectivity comparable to the pyroelectric with about 1000 times faster response:

"Microbolometers for Infrared Detection," by T.L. Hwang, S.E. Schwarz, and D.B. Rutledge, Appl. Phys. Lett. 34, 773-776 (1 June 1979).

Abstract:

We describe a novel room-temperature detector for the wavelength range 10-1000 microns. This detector consists of a thin bismuth bolometer film with dimensions much smaller than a wavelength. The small size of the detector results in reduced NEP and faster response. A video NEP of 1.6×10^{-10} W/Hz$^{1/2}$ is obtained at 119 μm, remaining within a factor of ten of this value for modulation frequencies up to 25 MHz. When used as a mixer, the device is predicted to have an NEP of 3.5×10^{-18} W/Hz. It is easily fabricated with conventional planar processing techniques and can be replicated in arrays. The device is expected to be most useful when radiation to be detected is spatially coherent.

A co-operative project has been developed with the Tokamak laboratory at Princeton University, intended to solve a problem with fusion-plasma diagnostics. We are presently constructing what we hope will be ruggedized versions of the microbolometer for installation in their 118-micron plasma interferometer. We hope to perform this experiment by the end of August, 1979.

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III. The personnel who have received support at various times under this grant are:

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